Fusion power measurement with gamma rays via the T(D,γ)^{5}He reaction and prospects for ITER

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Fusion power measurement is a mandatory plasma parameter that is currently solely measured by absolute counting of the neutrons emitted during the fusion process. In magnetic confined devices, neutron counting involves the use of fission chamber detectors placed around the machine, cross-calibrated with absolute activation foil measurements. The absolute neutron yield is then determined rescaling point-wise measurements to the total neutrons emitted by the plasma through heavy MCNP simulations, benchmarked with in-vessel neutron calibration campaigns. Forty years of experience at JET demonstrated that an accuracy of about 10% can be achieved. However, future reactors require a second independent method for fusion power validation and licensing.

This contribution will present an alternative neutron-independent method called GETART based on the absolute counting of gamma rays emitted via the T(D,γ)^{5}He fusion reaction. The method was benchmarked at JET during the DTE2 campaign by using a $LaBr_3$ scintillator detector. The ^{5}He γ ray decay spectrum was measured for the first time [1] confirming the presence of two γ ray lines and assessing their relative intensities. By counting these γ rays and using the JET neutron camera the total γ ray emission can be measured, and thus, if γ to neutron branching ratio is known, the DT fusion power [2]. The last part of the contribution will outline the prospects of the GETART method for ITER, with the use of the Radial Gamma Ray Spectrometer diagnostic that feature a set of $LaBr_3$ detectors observing the plasma along four different lines of sights. The combined use of these lines of sights can provide a second independent measurement of the ITER fusion power, crucial for licensing and validating the conventional neutron-based methodology.

[1] M. Rebai et al., "First spectral measurement of the 3H(2H, γ)5He reaction emission lines and assessment of γ1 and γ0 yields", manuscript submitted for publication to Physical Review C (2024).

[2] A. Dal Molin et al., "Measurement of the gamma-ray to neutron branching ratio for the deuterium-tritium reaction from magnetic confinement fusion experiments at the Joint European Torus", manuscript submitted for publication Physical Review Letters (2024)